

ELECTRONIC FUNDAMENTALS

EXPERIMENT LESSON 30

OSCILLATOR EXPERIMENTS



RCA INSTITUTES, INC.
A SERVICE OF RADIO CORPORATION OF AMERICA
HOME STUDY SCHOOL
350 West 4th Street, New York 14, N. Y.

Experiment Lesson 30

INTRODUCTION

All oscillators require feedback to operate. Different kinds of oscillator circuits have different kinds of feedback. In order to support oscillation, the signal fed back must be in phase with the signal at the grid of an oscillator. In this lesson you will build the local-oscillator stage of your receiver, and experiment with several methods of obtaining the feedback needed to support oscillation. These experiments will confirm that the signal fed back must be in-phase, will show that grid bias for the oscillator results from the a-c signal that the oscillator generates, that the bias is dependent upon the a-c signal, and that the value of the d-c bias voltage is proportional to the strength of the a-c signal.

You will observe an effect called *oscillator blocking*, which can cause an oscillator to stop oscillating. You will use this effect to cause the oscillator to stop and start at a periodic rate and thus deliver bursts of r-f signal. In modifying the circuit to work in this way, you will be building what is called a *blocking oscillator*.

In this lesson you will learn how to measure frequency. You will measure the frequency of the signal generated by the oscillator that you build. And your experiments will show that the frequency of the signal is determined mainly by the resonant frequency of the tuned circuit employed in the oscillator. Your experiments will also show what kind of effect other circuit components in the oscillator have upon frequency.

EQUIPMENT NEEDED

- One 6SA7 tube
- One octal-tube socket with mounting hardware
- One oscillator coil
- One padder capacitor
- One 50- $\mu\mu\text{f}$ fixed mica capacitor
- One 470- $\mu\mu\text{f}$ fixed mica capacitor
- One 22 k-ohm $\frac{1}{2}$ -watt resistor
- One 1,500-ohm $\frac{1}{2}$ -watt resistor
- One 10-megohm $\frac{1}{2}$ -watt resistor
- One 100 k-ohm $\frac{1}{2}$ -watt resistor
- Magnet wire
- Hook-up wire
- One 2-lug terminal strip
- Spaghetti
- Vinyl tape
- Signal generator
- Multimeter

JOB 30-1

To become familiar with the 6SA7 characteristics as given in the tube manual.

Procedure.

Step 1. Look up the 6SA7 tube in the

tube manual and fill out the following:

Type of tube: pentagrid converter

Glass or metal envelope: metal

Type of base: octal

Heater voltage: 6.3 v

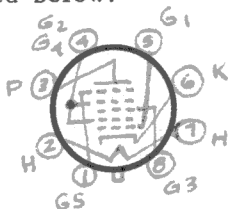
Heater current: .3 amp

Maximum plate voltage: 300 v

Maximum grids No. 2 and

No. 4 voltage: 100 v

Step 2. Draw the basing diagram in the circle provided below:



Information. The 6SA7 tube is actually two tubes in one. It serves as both an oscillator and a mixer in your radio. When a single tube has these two separate functions, it is called a converter.

The cathode of the 6SA7 tube is common to both functions. Grid 1 is the control grid for the oscillator circuit. Grid 2 is the equivalent of a plate for the oscillator. The cathode, grid 1, and grid 2 are the three elements of the 6SA7 that you will work with in this lesson. The remaining elements will be studied in a later experiment lesson.

Briefly, the full tube works as follows in the complete converter circuit that will be completed in future experiment lessons. Feedback is taken from the grid 2 circuit, and applied to the grid 1 circuit to cause oscillation. The oscillatory voltage exists on grid 1. Therefore, it exercises control over the electron stream reaching the plate (P). The r-f broadcast-station-signal voltage is applied to grid 3, and also exercises control over the electron stream reaching the plate (P). The broadcast signal and the

oscillator signal combine at the plate (P). Mixing action (to be described in future lessons) takes place at the plate (P). Grids 2 and 4, which are joined together, have B+ voltage applied to them, but are kept at signal ground potential by means of a bypass capacitor. Grid 2 serves as plate for the oscillator circuit and also serves to accelerate the electron stream—which varies in intensity with the oscillator signal—towards the real plate (P) of the 6SA7 tube just as a screen grid would do. Grid 4 serves as screen grid to the broadcast-signal control grid 3.

JOB 30-2

To prepare a tickler coil for use in the oscillator experiments.

Procedure.

Step 1. Cut off a 4-foot length of magnet wire.

Step 2. Cut off two 3-inch lengths of thin spaghetti to fit over the magnet wire.

Step 3. Cut off a 6-inch length of vinyl tape and split it lengthwise in halves as shown in Fig. 30-1a.

Step 4. Wind the magnet wire loosely around the prongs of the 6SA7 tube to form a coil, as shown in Fig. 30-1b. Allow the turns of the coil to overlap haphazardly.

Step 5. Grasp the turns of the coil so that they cannot spring apart and remove the coil from the prongs of the tube.

Step 6. Holding the coil between thumb and index finger of one hand, and holding your oscillator coil in the other hand, try to slip the oscillator coil through the circle made by the turns of the tickler coil (Fig. 30-1c). You will find that the three terminals of the oscillator coil do not fit within the turns of the tickler coil.

Step 7. Now put the oscillator coil down and use both hands to enlarge the circle

made by the turns of the tickler coil. To do this, allow the turns to spring apart as you shift the thumb-and-forefinger grip you hold upon the tickler coil. Shift the grip from one hand to the other—back and forth—until the

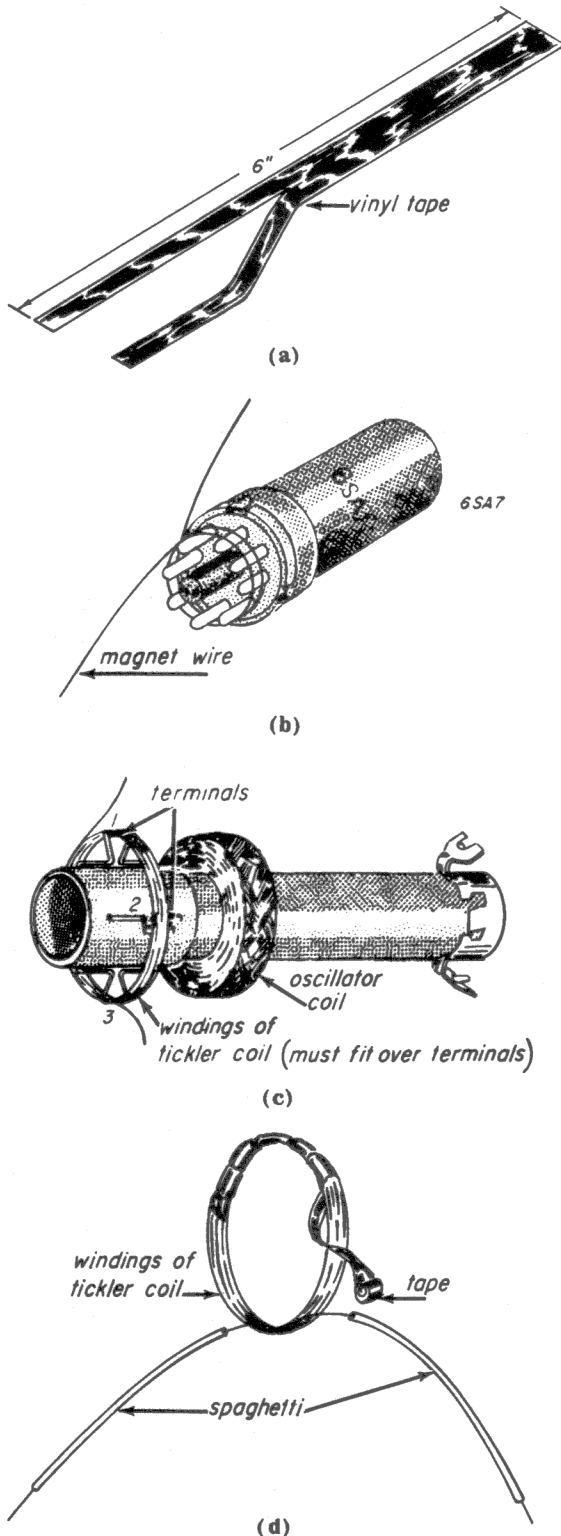


Fig. 30-1

circular hole in the tickler is large enough to slip easily over the three lugs of the oscillator coil (Fig. 30-1c).

Step 8. Using the half strips you have cut from the 6-inch length of vinyl tape, tape the coil as shown in Fig. 30-1d and install the three-inch lengths of spaghetti over the two leads of the coil.

JOB 30-3

To prepare the radio receiver chassis for the next series of experiments.

Information. At the conclusion of these experiments you will have wired up the local-oscillator stage of your receiver. At that point, as shown in the schematic of Fig. 30-2a, you will have a Hartley oscillator. Right now you will wire the circuit as shown in Fig. 30-2b. The difference between the circuit at *b* and the final circuit at *a* is that the 6SA7 cathode is returned to ground

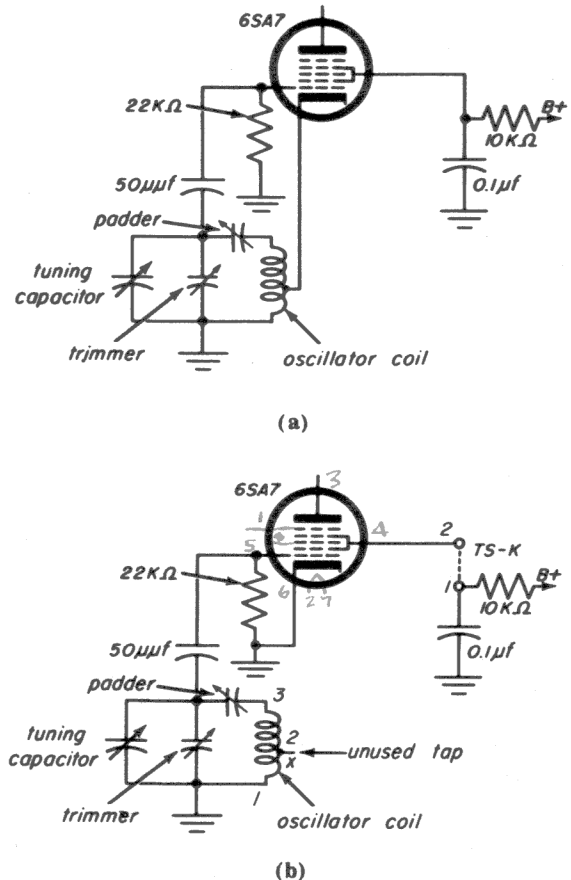


Fig. 30-2

at *b* rather than to the tap on the oscillator coil as at *a*. This wiring difference disconnects the feedback path that is a part of the circuit at *a*. The circuit at *b* is without feedback and will not oscillate unless some method of applying feedback is added to the circuit.

Procedure.

Step 1. Remove the following temporary wiring, which is left over from previous experiment lessons.

a. The filament lead connecting pin 4 of the 6BA6 r-f tube to pin 3 of the 6AT6 audio tube.

b. Remove the 0.1- μ f capacitor connecting pin 6 of the 6BA6 i-f tube to ground.

Step 2. Remove the r-f tube (6BA6) and

the i-f tube (6BA6) from their sockets and put them aside in a safe place.

Step 3. Install the 6SA7 octal socket in its hole. Make sure that pins 1 and 8 are towards the front of the chassis as shown in Fig. 30-3. Fasten the socket with No. 6-32 screws and hex nuts.

Step 4. Mount a two-lug terminal strip as shown in Fig. 30-3. This terminal strip will be referred to as TS-K in this lesson.

Step 5. Prepare the oscillator coil for mounting as follows:

a. Grasp one of the flanges of the spring-clip mounting mechanism (Fig. 30-4) in the jaws of your long-nose pliers. Apply light rotary pressure to the spring-clip flange so that it bends slightly away from the cardboard-coil form.

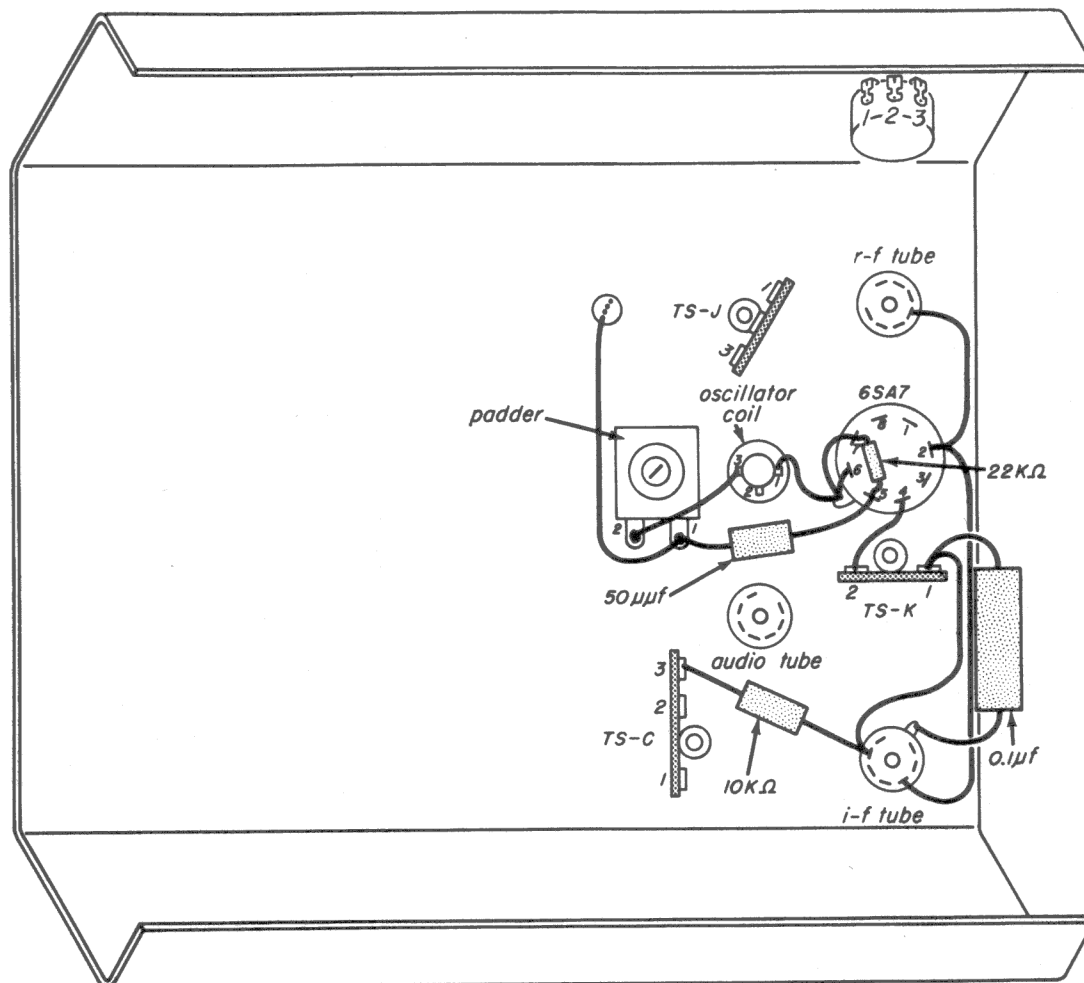


Fig. 30-3

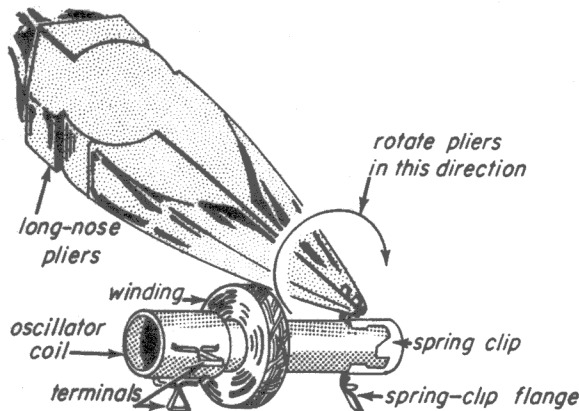


Fig. 30-4

b. Repeat the above procedure with the other flange of the spring clip.

c. Remove the spring clip from the coil form.

d. Reinstall the spring clip on the coil form. However, position it so that the little metal projection which is part of one of the flanges lines up with lug 1 (Fig. 30-3) of the coil.

Step 6. Install the coil in its chassis mounting hole. Make sure the little projection goes into its place in the mounting hole. Make sure the coil is firmly in place.

Step 7. Mount the padder capacitor as shown in Fig. 30-3. Make sure the terminals face the rear of the chassis.

Step 8. Now you are ready to wire the oscillator coil into the circuit. Be sure to dress the leads as shown in Fig. 30-5. Position the leads parallel to the coil form and as close to the coil as possible. Run the leads from the terminal lugs of the coil down to the chassis and then to their destination. Do not suspend the leads away from the chassis. The purpose of dressing the leads in this way is to allow for sliding the tickler coil that you have made over the wired oscillator coil. Connect terminal 1 of the oscillator coil to the tube socket ground lug as shown in Fig. 30-3. Connect terminal 3 of the oscillator coil to terminal 2 of the padder capacitor (Fig. 30-3).

Step 9. Connect terminal 1 of the padder capacitor to the stator lug of the rear section

of the ganged tuning capacitor. Run the connecting wire through the hole in the chassis (Fig. 30-3) that is located below the stator lug.

Step 10. Connect the 50- $\mu\mu\text{f}$ fixed mica capacitor from terminal 1 of the padder to pin 5 of the 6SA7 socket. Also connect one lead from the 22 k-ohm $\frac{1}{2}$ -watt resistor supplied in your kit to pin 5 of the 6SA7.

Step 11. Do the following in order to complete the permanent filament wiring of your receiver:

a. Connect a lead from pin 3 of the 6BA6 i-f tube to pin 2 of the 6SA7.

b. Connect another lead from pin 2 of the 6SA7 to pin 4 of the 6BA6 r-f tube. Dress these leads into the corner of the chassis as shown in Fig. 30-3.

c. Wire pin 7 of the 6SA7 to the ground lug of the 6SA7 socket as shown.

Step 12. Connect one end of a 4-inch length of hookup wire to pin 6 of the 6BA6 i-f tube.

The wiring in the following steps is temporary.

Step 13. Connect the free end of the lead from pin 6 of the i-f tube (this is a B+ wire) to terminal 1 of TS-K. Connect the 0.1- μf capacitor from terminal 1 of TS-K to chassis (Fig. 30-3). Be sure to ground the foil end of the capacitor.

Step 14. Connect a lead from pin 4 of the 6SA7 to terminal 2 of TS-K.

Step 15. Connect the free lead of the 22

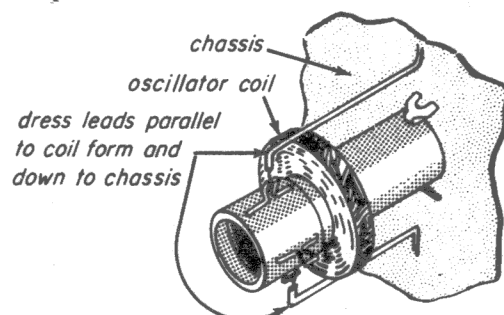


Fig. 30-5

k-ohm resistor on pin 5 of the 6SA7 to pin 7 (a ground point) of the 6SA7.

Step 16. Connect the cathode, pin 6 of the 6SA7 to chassis.

Step 17. Install the 6SA7 tube in its socket.

Step 18. Recheck your wiring to be sure that it conforms to the schematic Fig. 30-2b, and to the pictorial wiring diagram, Fig. 30-3.

EXPERIMENT 30-1

To show that a signal can be coupled into the oscillator coil by means of the tickler coil.

Procedure.

Step 1. Connect your $470\text{-}\mu\text{f}$ mica capacitor from terminal 2 of the oscillator padder capacitor to pin 6 of the 6AT6 audio tube.

Step 2. Slip the tickler coil over the oscillator coil and position the tickler

directly over the winding of the oscillator coil.

Step 3. Connect the ground lead from your signal generator to one lead from the tickler and connect the hot lead from the signal generator to the remaining lead from the tickler. Turn on the generator and the radio.

Information. The circuit you are working with, as it stands now, is shown schematically in Fig. 30-6. A modulated r-f signal from the generator will be coupled into the oscillator coil, which is part of a tuned tank circuit. The signal will then be coupled out of the tuned circuit by means of the $470\text{-}\mu\text{f}$ capacitor and applied to the diode plate of your receiver's detector circuit. Here the 400-cps modulation is removed from the r-f signal, amplified in the receiver audio stages, and applied to the loud speaker. When you hear the 400-cps tone, you know that the r-f signal is being coupled into the oscillator coil by means of the tickler coil.

Step 4. Turn the r-f output of the signal generator to maximum; turn on the modulation.

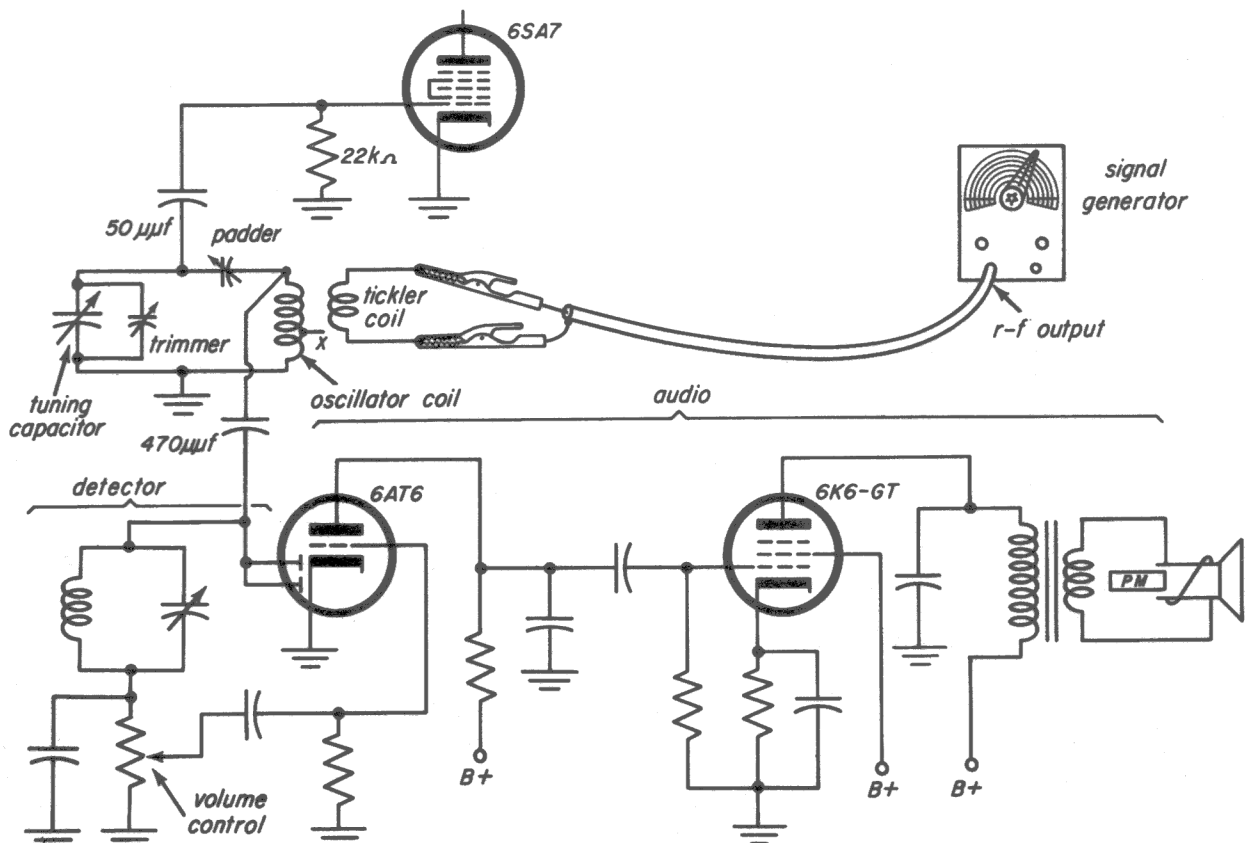


Fig. 30-6

Step 5. Turn the radio volume to maximum.

Step 6. Set the radio tuning capacitor at slightly less than the full clockwise position.

Step 7. Set the signal generator on band B and rotate the frequency control until the 400-cps tone is loudest.

Step 8. Note that if you alter the setting of either the signal-generator-frequency control or the receiver tuning capacitor, the 400-cps tone becomes weaker.

Step 9. Note that if you move the tickler coil away from the oscillator coil, the tone becomes weaker.

Step 10. Turn off the receiver.

Discussion. The tickler coil couples the signal to the oscillator coil by transformer action. The tickler coil is the primary of the transformer and the oscillator coil is the secondary. If you separate the tickler from the oscillator coil, you reduce the magnetic coupling.

Since the oscillator coil is part of a tuned tank circuit, most signal can be coupled into the tank at its resonant frequency. The tone is loudest when signal generator and tank are at the same frequency. Changing the setting of the generator frequency control causes it to deliver a signal at a frequency other than that to which the tank is tuned. Thus the 400-cps tone sounds weaker. Changing the setting of the tuning capacitor changes the frequency to which the tank is tuned so that it gets retuned to a new frequency which is different than the frequency of the signal from the generator. Again the 400-cps tone sounds weaker.

EXPERIMENT 30-2

To show that cathode, grid 1, and grid 2 of the 6SA7 can function as a triode r-f amplifier in which grid 2 serves as plate.

Procedure.

Step 1. Alter the previous circuit by disconnecting the lead of the 470- μf capacitor

which is connected to terminal 2 of the padder. Connect this lead of the 470- μf capacitor to terminal 2 of TS-K.

Step 2. Connect the 100 k-ohm resistor from terminal 1 to terminal 2 of TS-K.

Information. The circuit is now connected as shown in the schematic, Fig. 30-7.

Step 3. Position the tickler coil directly over the oscillator coil winding.

Step 4. Turn on the radio, volume at maximum.

Step 5. Set the signal generator r-f output at maximum, modulation on, and rotate the frequency control until the 400-cps tone sounds loudest.

Step 6. Note that the tone is louder than it was in Experiment 30-1. If you do not want to rely upon your sense of hearing, connect your output meter to the plate of the 6K6-GT tube and repeat Experiments 30-1 and 30-2. Compare the reading obtained in this experiment with one taken under the conditions specified in Experiment 30-1. We measured 15 volts a.c. in Experiment 30-1 and 30 volts a.c. in Experiment 30-2.

Discussion. You know that the 6SA7 tube amplifies with grid 2 as plate and grid 1 as control grid because — whereas you are coupling the same amount of signal to the oscillator coil as in Experiment 30-1 — now you take the signal to be detected from grid 2 rather than from the oscillator coil and the tone sounds louder.

EXPERIMENT 30-3

To show that if some of the amplified output signal from grid 2, acting as plate of the 6SA7 is fed back in proper phase to the oscillator coil at grid 1, the circuit will oscillate.

Procedure.

Turn off the radio.

Step 1. Remove the 470- μf capacitor. Remove the 100 k-ohm resistor from TS-K

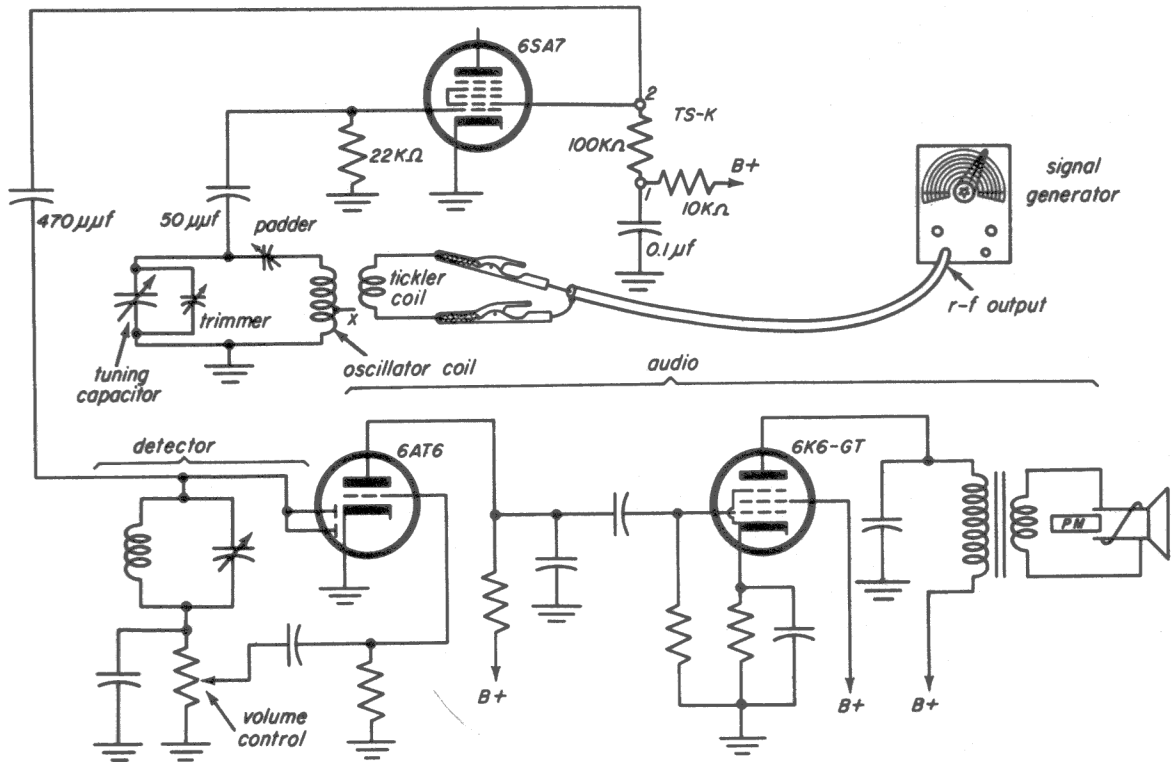


Fig. 30-7

and disconnect the signal generator cable from the tickler coil. Turn off the generator.

Step 2. Remove the tickler from the oscillator coil and connect one lead of the tickler to terminal 1 of TS-K; connect the other lead of the tickler to terminal 2 of TS-K.

Step 3. Set the tuning capacitor at maximum clockwise. Turn on the radio.

Step 4. With the tickler wired to TS-K but not yet placed over the oscillator coil, measure the negative grid potential on grid 1, pin 5 of the 6SA7, using the 5 VDC scale. Record your reading here:

-3
volts d.c.

Your meter reading should be about -0.2 volts d.c. This is contact potential; the tube has no bias.

Turn off the radio.

Step 5. Position the tickler coil over the oscillator coil and line up the windings of the two coils. Turn on the radio.

Step 6. Measure the grid potential as in Step 4, and record your reading here:

-3
volts d.c.

Turn off the radio.

Step 7. Remove the tickler from the oscillator coil; turn the tickler coil over and replace it on the oscillator coil. Turn on the radio.

Step 8. Measure the grid potential as in steps 4 and 6 and record your reading here:

-14
volts d.c.

Discussion. Your meter readings in steps 6 and 8 depend upon the way in which you

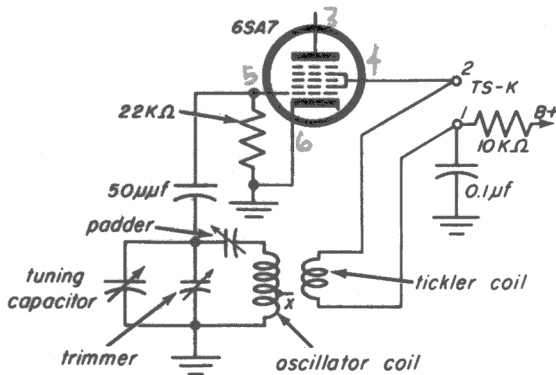


Fig. 30-8

happen to place the tickler coil. The reading in one of these steps (either Step 6 or Step 8) should equal your reading in Step 4. However, one of the readings (either in Step 6 or in Step 8) should be about -15 volts. This is bias. It is signal bias — a d-c grid voltage that results from grid rectification of an a-c signal. Since you are applying no a-c signal to the circuit, the presence of signal bias tells you that the circuit is oscillating and generating an a-c signal. You will study oscillator bias in more detail in later experiments in this lesson. For now, the important thing is that when the bias is present, the circuit is oscillating.

A schematic of the oscillator circuit that you are experimenting with is shown in Fig. 30-8. This is a *tickler feedback* or *Armstrong oscillator*. Feedback is returned from the plate (grid 2) to the control grid (grid 1) of the oscillator by means of the tickler. The absence of grid bias in Step 4 when the tickler was not in place over the oscillator coil shows that the circuit was not then oscillating. When the tickler was placed over the oscillator coil in the appropriate way, grid bias voltage appeared. This took place either in Step 6 or in Step 8. However, when the tickler coil was reversed (Step 6 or Step 8), there was no bias voltage at the grid, indicating no oscillation. This confirms what we have said; that in order to support oscillation, feedback must be in phase with the grid signal. Turning the tickler coil over reverses the phase of the signal fed back since doing so reverses the direction of current flow in the tickler coil with respect to the direction in which current is flowing in the oscillator coil.

EXPERIMENT 30-4

To further confirm that the circuit of Fig. 30-8 is actually oscillating and generating an a-c signal. To show that, in this oscillator circuit, the signal is present at the plate of the oscillator (grid 2).

Information. You are going to use your multimeter to indicate the presence of the r-f signal. However, your meter was not designed to measure r-f voltage. The scale-multiplier resistors in your meter do not function when an r-f signal is applied to the meter. To get around this, you will use an external 1,500-ohm resistor as multiplier so that the meter pointer will not deflect too far off scale. Do not expect your r-f readings to correspond exactly to the readings obtained in our laboratory. You are not concerned with the actual voltage quantities measured, but only with the presence or absence of any r-f voltage at all. This is indicated by the presence or absence of pointer deflection. Caution: Close contact between the meter leads and your hands or body can reduce the r-f readings. Twisting the leads also can reduce the r-f readings.

Procedure.

Step 1. Put your 1,500-ohm $\frac{1}{2}$ -watt resistor in series with a meter probe and plug into the OUTPUT jack on the meter. Ground the other probe, which should be plugged into the COMMON jack. Set the RANGE switch on any voltage range. Set the FUNCTION switch to AC. Turn on the radio.

Step 2. Place the probe with resistor in series on terminal 3 of the oscillator coil. Note that the meter pointer deflects. If not, recall that the tickler must be placed so as to give in-phase feedback, as in Exp. 30-3. Also line up the two coils.

Step 3. Place the probe on the plate (grid 2) of the oscillator (pin 5 of the 6SA7). Note that the pointer deflects.

Step 4. Place the probe on the cathode (pin 6) of the 6SA7. Of course, the pointer does not deflect. The cathode is grounded.

EXPERIMENT 30-5

To show that the oscillator generates most r-f voltage when the tickler is closest to the oscillator coil winding. This is so because feedback is then greatest. To show that the d-c signal bias voltage is greatest when the r-f voltage generated is greatest, because feedback is then greatest.

Procedure

Step 1. Turn off the radio. Position the tickler coil over the oscillator-coil winding.

Step 2. Turn on the radio. Measure the r-f voltage at terminal 3 of the oscillator coil using the probe with the 1,500-ohm series multiplier resistor and with the probe plugged into the OUTPUT jack on your meter. Take your reading from the 15 VAC scale of the meter. Write your reading here:

15

We read 15 in our laboratory. This reading is by no means an indication of the actual value of r-f voltage present. Remember that the multipliers in the meter are not working properly, and also that the a-c meter calibration is meaningless at this frequency. It is used here for comparison only. Remember that touching the meter leads or twisting them reduces the r-f reading. Do not expect your readings to correspond exactly to ours.

Step 3. Change over the meter to the 25 VDC range and measure the d-c signal bias on pin 5 of the 6SA7. Turn off the radio. Record your reading here:

-13.5
volts d.c.

We measured -15 volts d.c. in our laboratory.

Step 4. Move the tickler coil away from the oscillator-coil winding and position it half way between the winding and the three terminal lugs of the oscillator coil. Turn on the radio.

Step 5. Set the FUNCTION switch back to AC, and measure the r-f voltage on terminal 3 of the oscillator coil as in Step 2:

7

We read 6 on the 15 VAC scale in our lab.

Step 6. Set the FUNCTION switch back to DC, and measure the d-c signal bias voltage at pin 5 of the 6SA7 as in Step 3:

-9
volts d.c.

We measured -6 volts d.c. in our laboratory.

EXPERIMENT 30-6

To show that feedback can be taken from the cathode as well as from the plate of the oscillator circuit.

Procedure.

Step 1. Disconnect the tickler coil from TS-K and disconnect the cathode (pin 6) of the 6SA7 from ground.

Step 2. Interconnect terminals 1 and 2 of TS-K.

Step 3. Connect one lead from the tickler coil to the cathode (pin 6) of the 6SA7. Connect the remaining lead from the tickler coil to ground.

Step 4. Position the tickler coil over the oscillator coil winding. Turn on the radio.

Step 5. Check with your meter for the presence of d-c signal bias voltage at the grid (pin 5) of the 6SA7. If no bias is present,

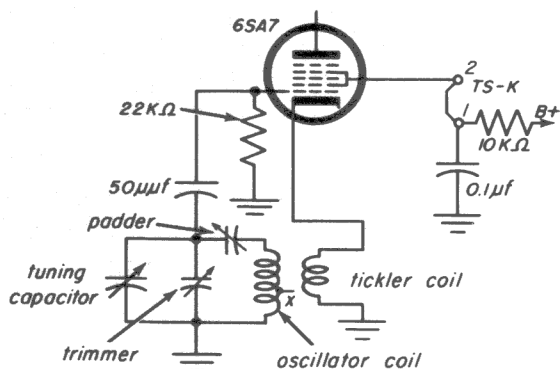


Fig. 30-9

reverse the tickler coil over the oscillator coil and check again.

Information. The oscillator circuit that you are now experimenting with is shown in the schematic of Fig. 30-9. Feedback is taken from the cathode rather than from the plate. When you measure d-c bias on the grid, you know the circuit is oscillating.

As shown in Fig. 30-9, the plate (grid 2, pin 4 of the 6SA7) is maintained at signal ground potential by the 0.1-μf bypass capacitor. Therefore, there should be no signal voltage at the plate of this oscillator, unlike the circuit of Fig. 30-8 (Experiment 30-4). However, signal should be present at the cathode (pin 6 of the 6SA7), from where it is fed back to the oscillator control-grid circuit by means of the tickler coil.

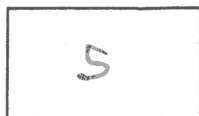
Step 6. To check for the presence of r-f voltage, set up your output meter with the 1,500-ohm external series multiplier resistor. Take the following readings from the 15 VAC scale on your meter:

- a. At the oscillator plate, grid 2, pin 4 of the 6SA7:



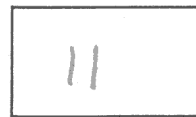
There should be no r-f voltage at this point.

- b. At the cathode, pin 6 of the 6SA7:



We obtained a reading of 6 in our laboratory.

- c. At terminal 3 of the oscillator coil:



We obtained a reading of 15 in our laboratory.

Discussion. We have shown that feedback can be taken from the cathode as well as from the plate of an oscillator tube.

EXPERIMENT 30-7

To show that instead of using a tickler coil to feed signal back from the cathode of the 6SA7 to the oscillator coil in the control-grid circuit, it is possible to apply feedback by connecting the cathode to a tap on the oscillator coil, thus making a Hartley oscillator.

Procedure

Turn off the radio.

Step 1. Disconnect the tickler coil and put it aside in a safe place.

Step 2. Wire the cathode (pin 6 of the 6SA7) to the tap (terminal 2) of the oscillator coil. Dress the wire down to the chassis and close to the coil to allow the tickler coil to fit over the oscillator coil.

Information. When you carry out Step 2, above, you will have completed wiring a Hartley oscillator. The schematic of this Hartley circuit is shown in Fig. 30-10. Note that it is much like the oscillator circuit of Fig. 30-9 except that, in Fig. 30-9, feedback is accomplished by straightforward transformer action between the tickler coil, as primary winding, and the oscillator coil, as secondary winding. In the Hartley circuit of Fig. 30-10, feedback is accomplished by auto transformer action between the lower (near ground) portion of the oscillator coil (terminals 2 and 1) and the entire oscillator coil (terminals 3 and 1) as secondary.

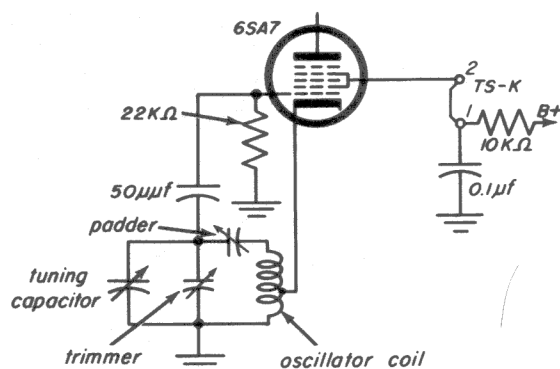


Fig. 30-10

Step 3. Turn on the radio. Measure the d-c signal bias at the control grid (grid 1, pin 5) of the 6SA7:

20
volts d.c.

We measured 10 volts d.c. in our laboratory.

Step 4. Set up your multimeter as an output meter using the 1,500-ohm external multiplier and take the following r-f readings from the 15 VAC scale on your meter.

a. At the oscillator plate, pin 4 of the 6SA7:

0

The reading should be zero.

b. At the cathode, pin 6 of the 6SA7:

2

We obtained a reading of 2 in our laboratory.

c. At terminal 3 of the oscillator coil:

3

We obtained a reading of 7.5 in our laboratory.

EXPERIMENT 30-8

To show that disconnecting the 22 k-ohm grid leak resistor will cause the oscillator to stop oscillating. This is caused by grid blocking.

Information. The higher the value of grid resistor in an oscillator, the more negative d-c signal-bias voltage is developed. When the resistor value is made very large (or omitted so that resistance is as large as possible), the negative bias becomes so great that the tube is biased to plate-current cutoff. No plate current flows and no r-f signal is generated. This is called grid blocking.

It is not possible to measure the negative bias voltage that cuts off the tube. When a meter is connected between grid and ground, its internal resistance becomes the grid resistor, and bias voltage decreases below the cutoff value. The tube no longer blocks. However, you can check the r-f signal at the cathode and the plate current with your meter while the tube is blocked. This is what you will do in this experiment.

Procedure.

Step 1. Turn off the radio. Unsolder the ground lead of the 22 k-ohm $\frac{1}{2}$ -watt grid resistor, which is connected to pin 5 of the 6SA7 and to chassis, but leave the lead that you disconnect in a position where it can be pushed against chassis ground momentarily for test purposes. Turn on the radio.

Step 2. Using your output meter set up with the external 1,500-ohm multiplier resistor, check the r-f signal at the cathode (pin 6 of the 6SA7) of the oscillator coil as follows:

a. With the unsoldered lead of the 22 k-ohm $\frac{1}{2}$ -watt grid resistor pushed (use a pencil or insulated probe) against chassis ground.

b. With the unsoldered lead of the 22 k-ohm grid resistor sprung away from ground. Note that, when the resistor is disconnected, the r-f signal disappears. Turn off the radio.

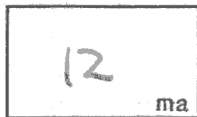
Step 3. Disconnect the jumper wire connecting terminals 1 and 2 of TS-K.

Step 4. Set your multimeter to measure current as follows:

- a. Range switch to the 100 MA position.
- b. Leads plugged into the COMMON (-) and POS (+) jacks.
- c. FUNCTION switch on DC.

Step 5. Connect the red probe of your meter to terminal 1 of TS-K. Connect the black probe to terminal 2 of TS-K. Turn the radio on.

Step 6. Push the unsoldered lead of the 22 k-ohm grid resistor against the chassis and note the current reading on your meter:



We measured 13 ma in our laboratory.

Step 7. Allow the resistor to spring away from chassis ground. The current reading should then be zero.

EXPERIMENT 30-9

To make use of the oscillator blocking effect to cause the oscillator to stop and start at a rapid periodic rate and deliver bursts of r-f signal.

To make a blocking oscillator.

Step 1. Turn off the set. Disconnect your meter from the circuit. Move the lead connecting pin 4 of the 6SA7 with terminal 2 of TS-K so that it connects pin 4 of the 6SA7 to terminal 1 of TS-K.

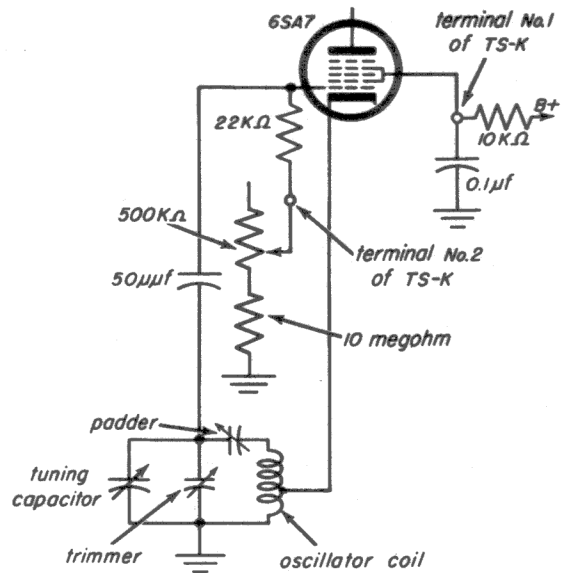


Fig. 30-11

Step 2. Connect the free ground lead of the 22 k-ohm $\frac{1}{2}$ -watt resistor to terminal 2 of TS-K. The resistor should now be connected between pin 5 of the 6SA7 and terminal 2 of TS-K.

Step 3. Connect a piece of hookup wire between terminal 2 of TS-K and terminal 2 of the unused potentiometer (the former bias control of Experiment Lesson No. 29).

Step 4. Connect your 10-megohm $\frac{1}{2}$ -watt resistor from terminal 1 of the potentiometer to the ground lug of TS-J.

Information. The schematic of the blocking oscillator is shown in Fig. 30-11. You have now completed wiring the grid circuit as shown in Fig. 30-11. The grid-leak resistor consists of a series combination of the 22 k-ohm resistor (which normally serves alone as grid leak) the 500 k-ohm *unused potentiometer* (which is here connected as a rheostat), and a 10-megohm resistor. The total value of the grid-leak resistor can be varied by turning the control shaft of the rheostat.

The operation of the circuit can be explained as follows. An oscillator with a grid leak of normal value generates a steady r-f voltage waveform as shown in Fig. 30-12a. When the value of the grid leak is very large,

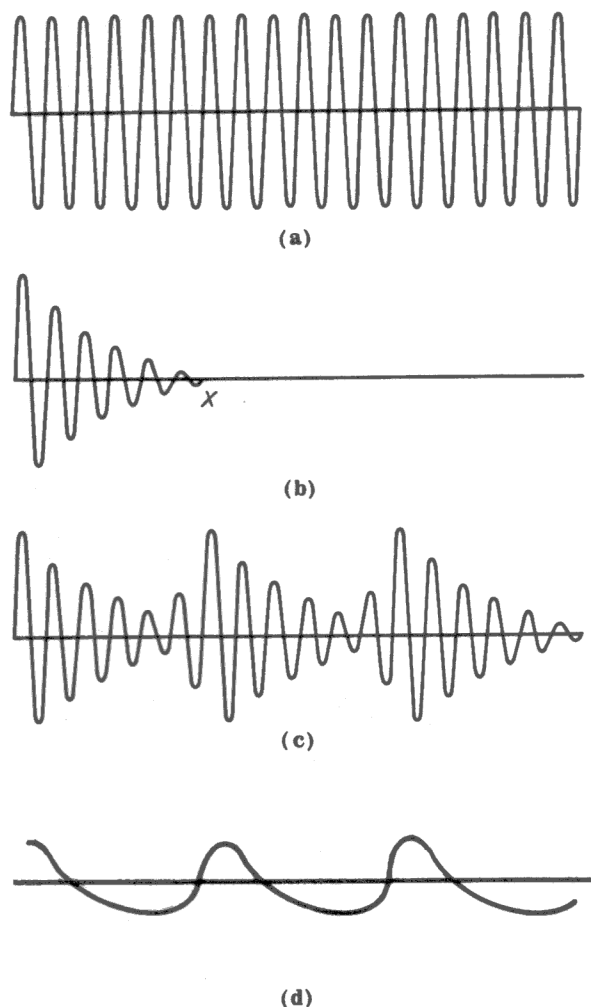


Fig. 30-12

as in Fig. 30-11, the amplitude of the r-f voltage gets lower and lower (Fig. 30-12b) as the d-c signal bias on the oscillator gets larger and larger. Finally, the oscillator stops (point X of Fig. 30-12b). When the oscillator stops, the bias disappears, so the oscillator starts again and repeats the dying out process. The result is an output signal made up of bursts of r-f voltage as shown in Fig. 30-12c.

You probably realize that the varying amplitude of the r-f cycles represents a modulation signal that can be removed by a detector. If the frequency of the modulation waveform (d) is an audio frequency, it can be heard when applied to a loud speaker. This is what you do in this experiment. The frequency at which the oscillator stops and starts — the modulation frequency — depends upon the value of the oscillator grid-leak re-

sistor. We have chosen a value that will cause an audiotone to come from the speaker.

The frequency (pitch) of the tone can be changed with the rheostat. You will use the tickler coil to couple the r-f bursts out of the oscillator and to the receiver diode detector where the audio modulation is removed from the signal. The resulting audio signal then goes through the radio audio amplifier to the speaker.

Step 5. Connect one lead from the tickler to the diode detector of your radio — pin 6 of the 6AT6 tube. Connect the remaining lead from the tickler coil to the ground lug of TS-J.

Step 6. Place the tickler coil over the oscillator coil winding. Turn on the radio.

Step 7. Set the receiver volume control at maximum. You should hear a high pitched tone.

Step 8. Turn the rheostat control through its range. Notice that this changes the pitch of the tone.

Step 9. Move the tickler coil away from the oscillator-coil winding. Notice that the loudness of the tone diminishes. This shows that the tone signal is actually carried on the r-f signal being picked up by the tickler from the oscillator coil.

Information. Experiment 30-8 shows that if the oscillator has no grid-leak resistor; it will block and completely stop oscillating. Experiment 30-9 shows that a very large value of grid-leak resistance causes the oscillator to stop and start periodically.

Within the range of grid-leak resistor values lower than that which causes periodic blocking, the oscillator will oscillate steadily. Nevertheless, within the range of grid-leak values that permit steady oscillation, varying the value of the grid-leak resistor varies the d-c signal-bias voltage value. Thus increasing the resistance within this range can change the bias class in which the oscillator tube operates from class

A to class B to class C. Class A operation results in a minimum of harmonic output from the oscillator, which is desirable in radio local oscillators. However, class A operation results in a lower amplitude of r-f output voltage. The 22 k-ohm grid resistor in your radio is chosen to produce a bias somewhat more negative than class A bias. If the 22 k-ohm resistor is increased, the negative bias voltage increases and the class of operation of the oscillator moves toward class C — the r-f output increases.

EXPERIMENT 30-10

To show that increasing the oscillator grid-leak resistor from 22 k-ohms to 122 k-ohms increases the negative d-c signal-bias voltage and increases the r-f signal output.

Procedure.

Step 1. Remove the lead connecting terminal 2 of the rheostat to terminal 2 of TS-K. Remove the 10-megohm resistor. Remove the tickler coil and put it aside in a safe place.

Step 2. Connect your 100 k-ohm $\frac{1}{2}$ -watt resistor from terminal 2 of TS-K to chassis ground.

Step 3. Short out the 100 k-ohm resistor with your clip lead so that only the 22 k-ohm resistor is in the circuit. Record the following readings:

a. The d-c bias voltage at the grid, pin 5 of the 6SA7:

10
volts d.c.

We measured 10 volts d.c. in our laboratory.

b. Using your output meter setup with the 1,500-ohm $\frac{1}{2}$ -watt series resistor, and reading from the 15 VAC scale, check the r-f

signal at the cathode (pin 6 of the 6SA7):

2

We obtained a reading of 12 in our laboratory.

Step 4. Remove the short across the 100 k-ohm resistor so that the total grid resistance becomes 122 k-ohms. Repeat a and b of Step 3, with the meter set for d-c volts.

a.

17
volts d.c.

We measured 17 volts d.c.

b.

4

Our reading was 5.5, read on the 15 VAC scale with the FUNCTION switch set to AC.

EXPERIMENT 30-11

To measure the frequency of the signal generated by your receiver local oscillator.

Procedure.

Step 1. Turn off the radio. Disconnect the 100 k-ohm resistor from the grid circuit.

Step 2. Disconnect the lead of the 22 k-ohm grid resistor that is connected to terminal 2 of TS-K. Permanently solder this lead to chassis ground at pin 7 of the 6SA7 tube.

Information. There are several methods for measuring the frequency of an a-c signal. The method you are going to follow is most used by radio servicemen. You are going to match up the r-f signal from your signal generator and the r-f signal from your receiver oscillator. When the two match up, the signal from the generator will be at the same fre-

quency as the signal from the oscillator. Since you can read the frequency of the generator from the frequency control dial, you will know the frequency of both signals.

To match up the two signals, you will make use of the principal that, when two signals are applied simultaneously to a detector, they combine to produce a third signal at a frequency that is equal to the difference between the frequencies of the two applied signals. The difference signal is called a *beat*. And the frequency of the difference signal is called a *beat frequency*. When the frequencies of the two applied signals are caused to be numerically close together, the beat frequency is in the audio range and can be heard in a loudspeaker. The closer that the frequencies of the two applied signals become, the lower is the pitch of the audio beat. When the two frequencies become exactly equal, the beat frequency is zero cycles per second and the speaker is silent.

In this experiment, you will apply the signal from your signal generator and that from your oscillator to your radio's detector.

Then you will vary the frequency of the signal from the generator until you get a zero beat. You will hear the audio beat signal in your radio loudspeaker because the detector is connected to the audio amplifier of your radio.

Step 3. Solder one lead from the tickler coil to the detector plate (pin 6), of the 6AT6 tube in your radio.

Step 4. Solder the remaining lead from the tickler to terminal 2 of TS-K.

Step 5. Place the tickler coil over the three terminals of the oscillator coil.

Step 6. Turn on your signal generator, and let it warm up. Connect the ground clip from the r-f cable of the generator to your radio chassis and connect the hot clip to terminal 2 of TS-K. Turn off the 400-cps modulation.

Information. The schematic of the setup you are working with is shown in Fig. 30-13. The signal from the generator goes through the wire of the tickler coil to the detector. At

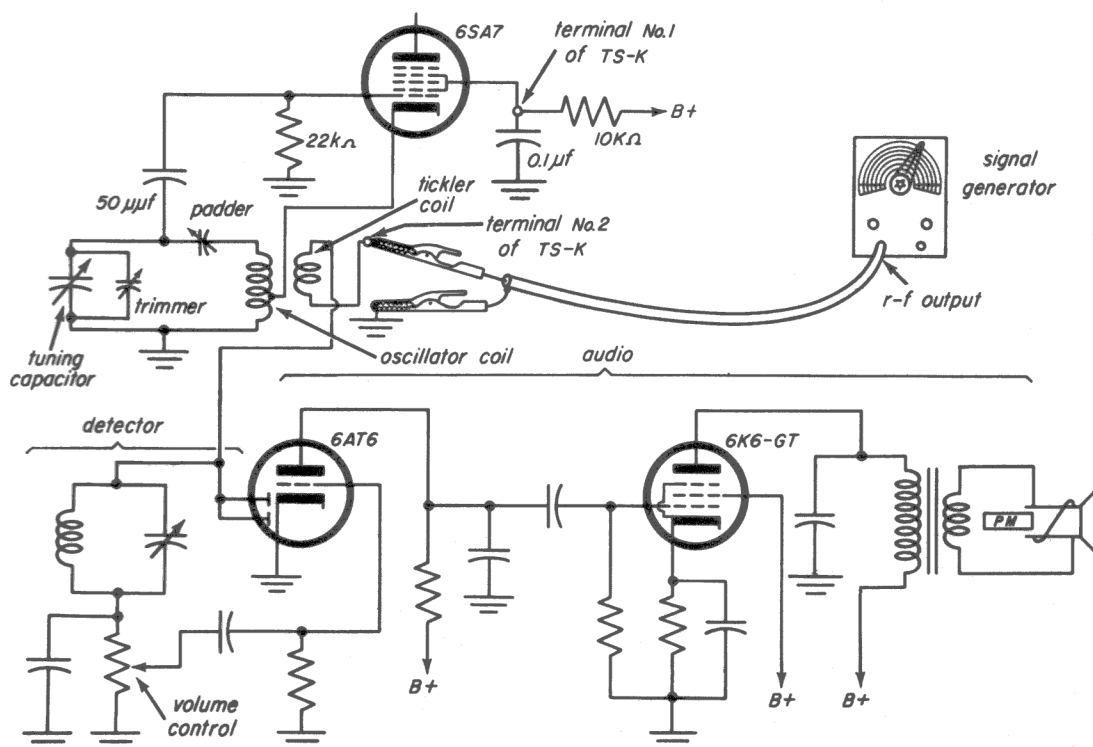


Fig. 30-13

the same time, the signal from the oscillator gets picked up by the tickler coil and is applied to the detector. Thus both signals are applied to the detector.

Step 7. Turn on the radio and set the tuning capacitor so that it is almost completely unmeshed, volume at maximum.

Step 8. Set the r-f output of the signal generator at maximum. Rotate the frequency control and listen to hear a beat frequency. The beat representing the frequency at which oscillator and generator signals match up should be in the vicinity of 1,700 kc at the high end of the dial on band B.

Note: As you rotate the frequency control through the point on the dial where the beat occurs, you hear a high pitched sound. As you continue to turn the control very slowly, the pitch of the sound gets lower, and lower. Finally, the pitch gets so low that the sound is like a dog's growl. After the growl, the sound stops. Then, as you continue to turn in the same direction, the growl starts again. Then it becomes a high-pitched tone. The pitch gets higher and higher until it is too high to hear. The silent point between the two audible beats is zero beat.

Step 9. Try to find a second beat at a point lower on the dial (about 850 kc) and a third beat at a point higher on the dial (around 3.5 mc on band C).

Information. Since it is possible to hear beats at three and more points on the dial, steps must be taken to eliminate the incorrect beats in order to accurately measure the oscillator frequency. If the output of the signal generator is set very low and very little signal is coupled out of the oscillator, the incorrect beats will be minimized in intensity or eliminated completely. Keeping the signals that are applied to the detector very weak is a necessary precaution that must always be taken when you measure frequency by the beat method. The remaining steps in this experiment are intended to show that reducing the generator signal

eliminates all unwanted beats at a frequency below the correct beat frequency. And reducing tickler coupling to the oscillator eliminates all beats above the correct beat frequency.

Step 10. Set the generator frequency dial to the lower beat. Very slowly turn the generator RF OUTPUT control to reduce the intensity of the sound. Stop immediately when the sound ceases. Now change the setting of the frequency control and notice that, although the sound is faint, you can still hear the correct beat and all higher beats.

Step 11. Set the frequency control at the beat frequency (about 3.5 mc) next higher than the correct beat frequency. Slowly move the tickler away from the oscillator coil and off the oscillator coil form (to reduce coupling) until the sound ceases. Change the setting of the frequency control and notice that the correct beat is now the only one you can hear at all. The frequency of this beat (around 1,700 kc) is the frequency at which the oscillator operates with the tuning capacitor almost fully clockwise. You can use the beat method to measure the oscillator frequency at any setting of the tuning capacitor. (With the converter stage incompletely wired, as it now is, the oscillator may intermittently stop oscillating at the extreme counter clockwise position of the tuning capacitor.)

Note: Probably you have observed that when the output signal of the generator and the signal picked up from the oscillator coil are both made weak enough to eliminate all but the correct beat, the correct beat is faint. You must pay close attention to the loudspeaker to hear the beat. This is always the case when the beat method of measuring frequency is in use. For this reason, earphones are employed instead of a loudspeaker by those who have reason to make many frequency measurements by the beat method.

Information. The resonant tank circuit, of which the tuning capacitor is a part, contributes most to determining the frequency of

the signal generated by the oscillator. Nevertheless, the values of other components in the circuit do effect the frequency, somewhat. Though slight, the effect that these other components have is important, because, if they are not stable — for example, if the value of a resistor changes as it heats up — the oscillator will drift in frequency. This can cause the tuning of a radio to drift off the station being received.

EXPERIMENT 30-12

To show that a slight change in the value of B+ voltage applied can cause a slight change in frequency.

Procedure.

Step 1. Set the signal generator and oscillator coupling to produce a loud audible beat (not zero beat).

Step 2. Set up your meter to monitor B+ on pin 4 of the 6SA7.

Step 3. Carefully grasp the insulated part (to avoid shock) of the 100 k-ohm $\frac{1}{2}$ -watt resistor in the jaws of your long-nose pliers. Hook the leads of this resistor over the leads of the 10 k-ohm 2-watt resistor soldered to pin 6 of the 6BA6 i-f tube. Notice that the B+ voltage increases slightly and the pitch of the audible beat changes slightly, indicating a slight change in oscillator frequency.

JOB 30-4

To complete the permanent wiring of your receiver local oscillator circuit.

Step 1. Turn off the radio. Disconnect the signal generator cable from the radio chassis.

Step 2. Unsolder and remove the tickler coil.

Step 3. Unsolder and remove the short piece of hook-up wire connecting pin 4 of the 6SA7 to terminal 1 of TS-K.

Step 4. Unsolder the two leads that remain at terminal 1 of TS-K. These leads are:

- a. A pig tail from the 0.1- μ f capacitor, the other pig tail of which is connected to chassis.
- b. A B+ lead, the other end of which is connected to pin 6 of the i-f tube.

Step 5. Remove TS-K.

Step 6. Permanently solder leads *a* and *b* above to pin 4 of the 6SA7. This completes the oscillator wiring which should appear as shown in Fig. 30-14. A schematic diagram showing the final condition of the chassis appears at the end of the lesson.

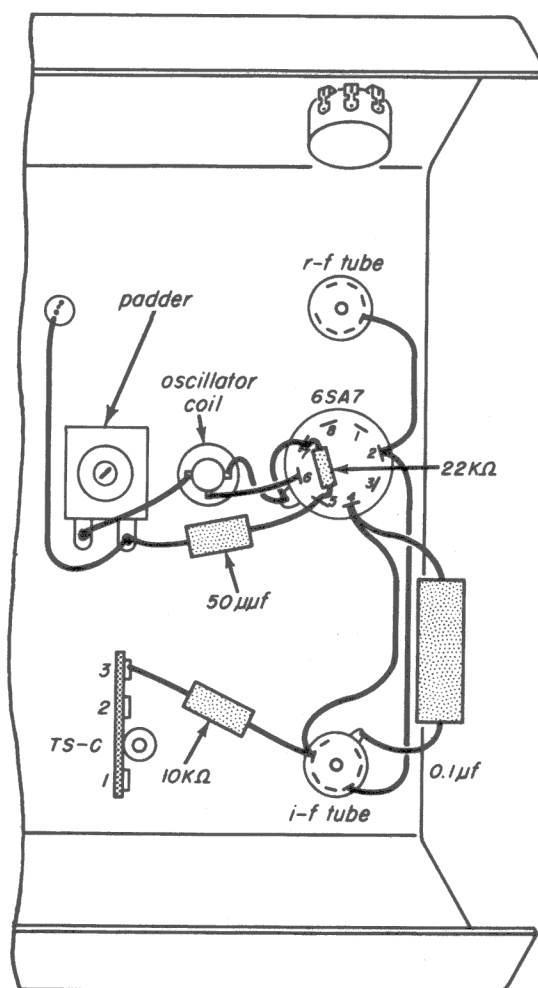
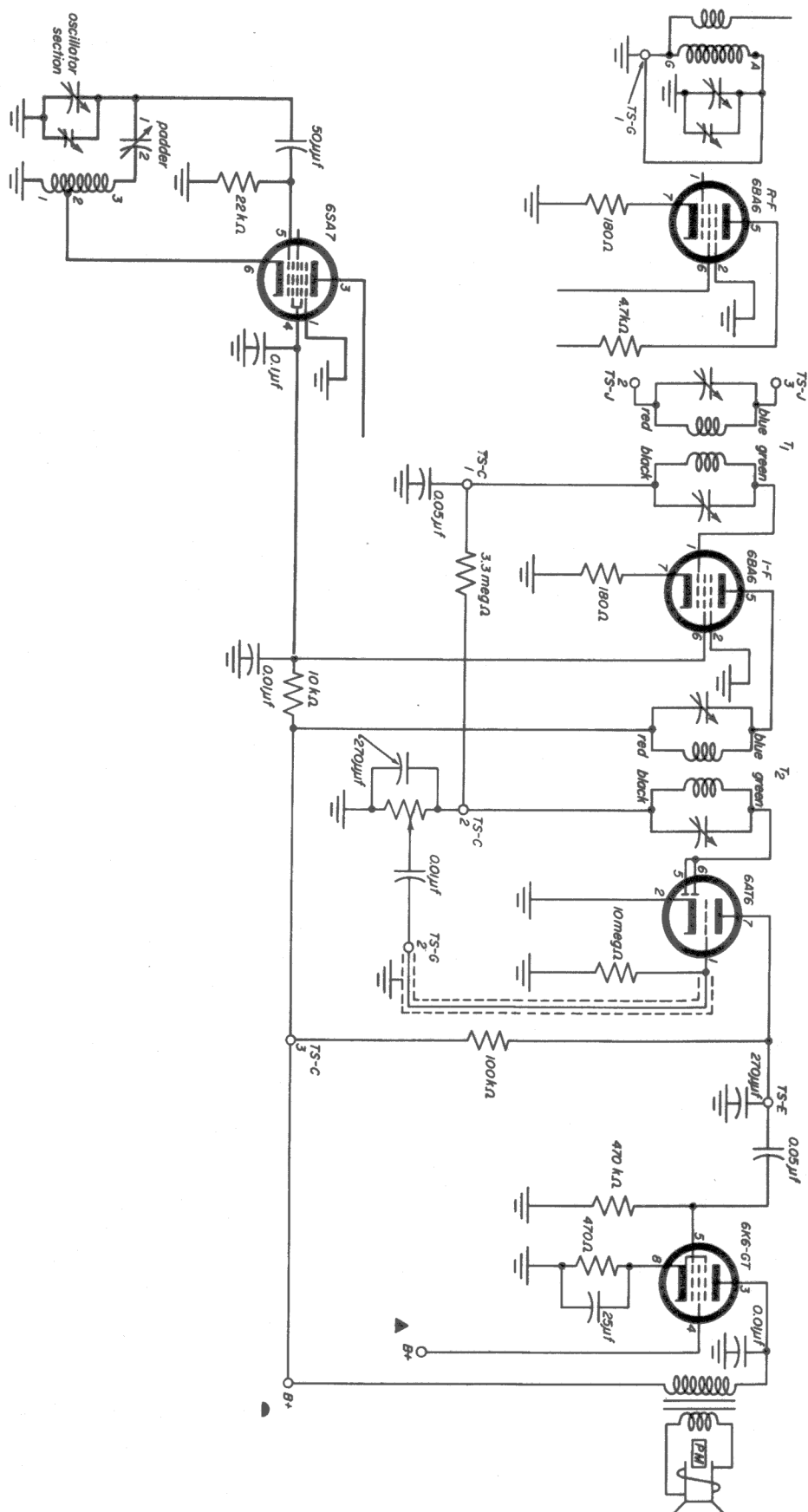


Fig. 30-14



Condition of Radio Receiver Chassis at End of Experiment Lesson 30